Asphalt Materials

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Tuttle, Oklahoma
Project area had seen over 100 accidents in the previous two years, many in wet weather.

Solution: Asphalt Permeable Friction Course

Project Length = 5 miles
Project Cost - $4.1 M
19,600 tons
Constructed over 4 weekends April-May 2009
HCTRA Engineer Quinton Alberto reported that they have been pleasantly surprised with:

- the ease of construction
- the short time to complete the project
- the aesthetically pleasing appearance of the project
- the performance in rain
- the quieter road noise
Performed a quick and easy noise study this morning (July 10, 2013)

Digital Sound Level Meter

Radio Shack - $49.99
Monitored PC Concrete section over a 5-minute period and recorded minimum and maximum readings

Min – 85 dB
Max – 96 dB

Digital Sound Level Meter
Radio Shack - $49.99
Monitored Asphalt PFC overlay section over a 5-minute period and recorded minimum and maximum readings

Min – 78 dB
Max – 90 dB
min 7 dB lower
max 6 dB lower

Digital Sound Level Meter
Radio Shack - $49.99
### OSHA Daily Permissible Noise Level Exposure

<table>
<thead>
<tr>
<th>Hours per day</th>
<th>Sound level</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>90dB</td>
</tr>
<tr>
<td>6</td>
<td>92dB</td>
</tr>
<tr>
<td>4</td>
<td>95dB</td>
</tr>
<tr>
<td>3</td>
<td>97dB</td>
</tr>
<tr>
<td>2</td>
<td>100dB</td>
</tr>
<tr>
<td>1.5</td>
<td>102dB</td>
</tr>
<tr>
<td>1</td>
<td>105dB</td>
</tr>
<tr>
<td>.5</td>
<td>110dB</td>
</tr>
<tr>
<td>.25 or less</td>
<td>115dB</td>
</tr>
</tbody>
</table>
Classifications of Asphalt

- Cutbacks
- Emulsions
- Asphalt Cement (Binder)
Cutback Asphalt

- Paving asphalt liquefied by blending with petroleum solvents
- Resulting material can be sprayed/mixed at lower temperatures
- Primary uses:
  - penetrating prime coat
  - binders for storable cold mix asphalt
Types of Cutback Asphalt

- **Rapid Curing (RC)**
  - ASTM D 2028
  - Gasoline or Naphtha
  - Asphalt

- **Medium Curing (MC)**
  - ASTM D 2027
  - Kerosene
  - Asphalt

- **Slow Curing (SC)**
  - ASTM D 2026
  - Diesel
  - Asphalt
Grades of Cutback Asphalt

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Asphalt Cement</th>
<th>Kinematic Viscosity mm²/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC-30</td>
<td>30 - 60</td>
<td>30 - 60</td>
</tr>
<tr>
<td>MC-70</td>
<td>70 - 140</td>
<td>250 - 500</td>
</tr>
<tr>
<td>MC-250</td>
<td>250 - 500</td>
<td>800 - 1600</td>
</tr>
<tr>
<td>MC-800</td>
<td></td>
<td>3000 - 6000</td>
</tr>
<tr>
<td>MC-3000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Asphalt Emulsions

• Microscopic asphalt droplets suspended in water.
• Mostly 1-5 μm diameter
• Emulsifiers or surfactants hold these droplets in suspension.
The purpose of diluting the binder with water is to lower the viscosity. This allows the emulsion to be shot onto the roadway surface at much lower temperatures than straight binder.

If the emulsifying agent causes the particles to bear a negative charge, the emulsion is said to be anionic.

If the emulsifying agent causes the particles to bear a positive charge, the emulsion is said to be cationic.
The process in which the binder globules begin to coalesce and the water evaporates is called *breaking*.

The amount of binder left after the water evaporates is called the *residual asphalt*.

The residual asphalt is expressed as a percentage of the emulsion.

Both the amount and type of water and emulsifying agent mixed with the binder affect the evaporation rate.
Emulsion

“Un-broken” emulsion is brown

“Broken” emulsion is black
Negatively-Charged Emulsions are classified into 3 types

RS (Rapid Setting)

MS (Medium Setting)

SS (Slow Setting)
Positively- Charged Emulsions are also classified into 3 types

- **CRS (Rapid Setting)**
- **CMS (Medium Setting)**
- **CSS (Slow Setting)**
Additional Nomenclature

QS = Quick Set
HF = High Float
1 = Binder residue = 60% Minimum
2 = Binder Residue = 65% Minimum
h = Hard Pen Asphalt Base
s = Soft Pen Asphalt Base or sometimes Solvent
l and/or p = Latex and/or Polymer
Anionic emulsions (negatively charged) typically bond best with positively charged aggregates (limestones, dolomites).

Cationic emulsions (positively charged) typically bond best with negatively charged aggregates (granites, sandstones).
Emulsions are further separated into different grades depending on various factors including viscosity, base asphalt type, and amount of residual asphalt.

The most common uses of emulsions are for chip seals, tack coats, and fog seals.
The term “binder” covers both neat (unmodified) and modified asphalt cements, but doesn’t include emulsions and cutbacks.

Binders are the “glue” that holds the aggregate together in HMA.

Unlike emulsions and cutbacks, binders are typically required to be heated to over 300°F for use, unless modified for use as Warm Mix Asphalt (WMA).

Polymers can be added to the binder to enhance their high temperature performance.
The grading system is based on Climate

PG 64-22

Performance Grade

Meets all requirements up to this temperature (°C)

Meets all requirements down to this temperature (°C)
High Temperature @ 98% Reliability
Low Temperature @ 98% Reliability
PG Binder Grades

The Rule of 92

PG 64-22 Probably Unmodified
PG 70-28 Probably Modified

This is the benefit of the modifier

TEMPERATURE °C

PG 64-22
PG 70-28

This is the benefit of the modifier
Asphalt Description and Sources

Asphalt Cement or Asphalt Binder

- Black, cementitious, waterproof material
- Originally mined from a natural lake (still operating today: Lake Asphalt of Trinidad and Tobago)
- Most asphalt today comes from the refining process
Not All Crudes Are The Same

• **Source**
  – Continents, Countries, States, Fields
  – Blends

• **Viscosity**
  – Heavy, Medium, & Light

• **Asphaltenes**
  – Content, Size, Polarity

• **Sulfur**
  – Sweet, sour
Not All Crudes Are The Same

Typical Crude Make-Ups

Venezuelan
- Asphalt Residue: 58%
- Hv. Gas Oil: 26%
- Lt. Gas Oil: 7%
- Residue: 3%

Arabian-Heavy
- Gasoline: 21%
- Kerosene: 28%
- Gas Oil: 14%
- Residue: 1%

Nigerian-Light
- Gasoline: 33%
- Kerosene: 20%
- Gas Oil: 16%
- Residue: 30%

Asphalt

Residue
Asphalt Behavior Depends On:

- Temperature
- Time of Loading
- Aging (properties change with time)
Asphalt is a *viscoelastic* material that has both the properties of an elastic solid and a viscous liquid, depending on the temperature.
Asphalt Flow Behavior

140°F  
1 hour

77°F  
1 hour

10 hours
Time of Loading
Asphalt aging over the pavement life

- Long-term, In-place Aging
- Mixing, Placing, and Compaction

Bulk Storage and Handling

Time

Aging

A
B
C
D1
D2
D3
High Temperature Behavior

• **High in-service temperature**
  – Desert climates
  – Summer temperatures

• **Sustained loads**
  – Slow moving trucks
  – Intersections

Viscous Liquid
Low Temperature Behavior

- Low Temperature
  - Cold climates
  - Winter
- Rapid Loads
  - Fast moving trucks

Elastic Solid
“Ideal” Asphalt Binder

- Low stiffness at construction temperature
- High stiffness at high in-service temperature
- Low stiffness at low in-service temperature
- Excellent long-term durability
Polymers

• Elastomers
• Plastomers
• Combinations

poly • mer

“many parts”
Elastomers

- Natural Latex Rubber
- Synthetic Latex
  - Styrene-butadiene (SB)
- Block Copolymer
  - Styrene-butadiene-styrene (SBS)
- Reclaimed Rubber
Plastomers

• Polyethylene
• Polypropylene
• Ethyl-vinyl-acetate (EVA)
• Polyvinyl-chloride (PVC)

EVA is a plastic that is used to create stiffer insoles for your shoes

Image courtesy cyclingfitness.com
This study (published in Feb 2005) used national field data to determine enhanced service life of pavements containing polymer modified binders versus conventional binders. The data is from a variety of climates and traffic volumes within North America.
Direct Comparisons – Rutting

Rut Depths on PMA Sections, inches

Rut Depths on Companion Sections, inches
Distress Comparisons – Transverse Cracking

Transverse Cracking - PMA Sections, ft.

Transverse Cracking - Companion Sections, ft.
Distress Comparisons – Fatigue Cracking

Fatigue Cracking - PMA Sections, %

Fatigue Cracking - Companion Sections, %
When would a polymer-modified asphalt typically be used?

AASHTO M 323 - Table 1

<table>
<thead>
<tr>
<th>ESALs (M)</th>
<th>Traffic Load Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standing</td>
</tr>
<tr>
<td>&lt; 0.3</td>
<td>-</td>
</tr>
<tr>
<td>0.3 - &lt; 3</td>
<td>2</td>
</tr>
<tr>
<td>3 - &lt; 10</td>
<td>2</td>
</tr>
<tr>
<td>10 - &lt; 30</td>
<td>2</td>
</tr>
<tr>
<td>≥ 30</td>
<td>2</td>
</tr>
</tbody>
</table>

* TxDOT guidance very similar, but less structured
Asphalt Materials

Questions?